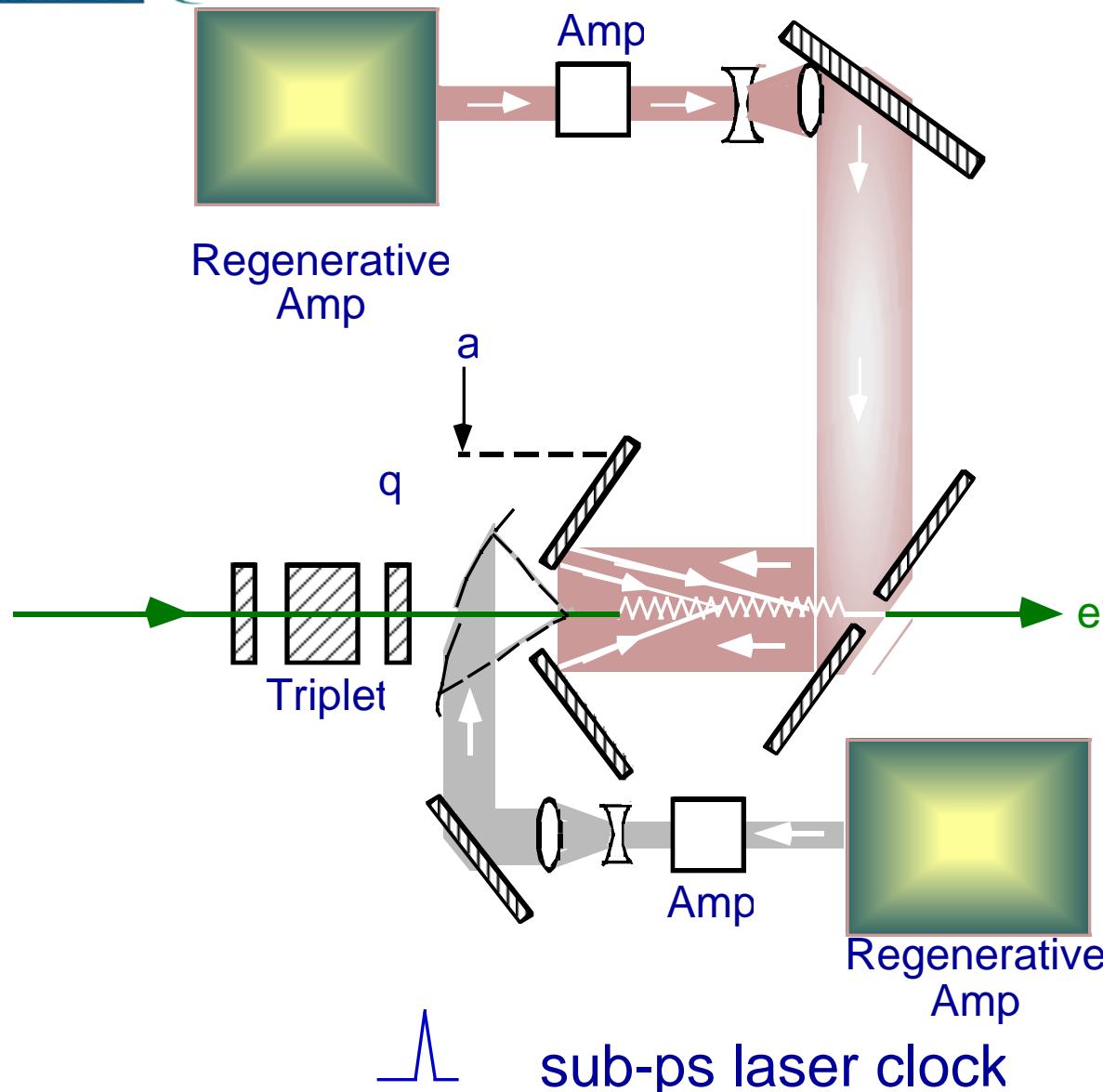




A 10 GeV Laser Wakefield Stage





Advanced Accelerator Concepts'96
Granlibakken, Lake Tahoe, CA
10/12-18/96



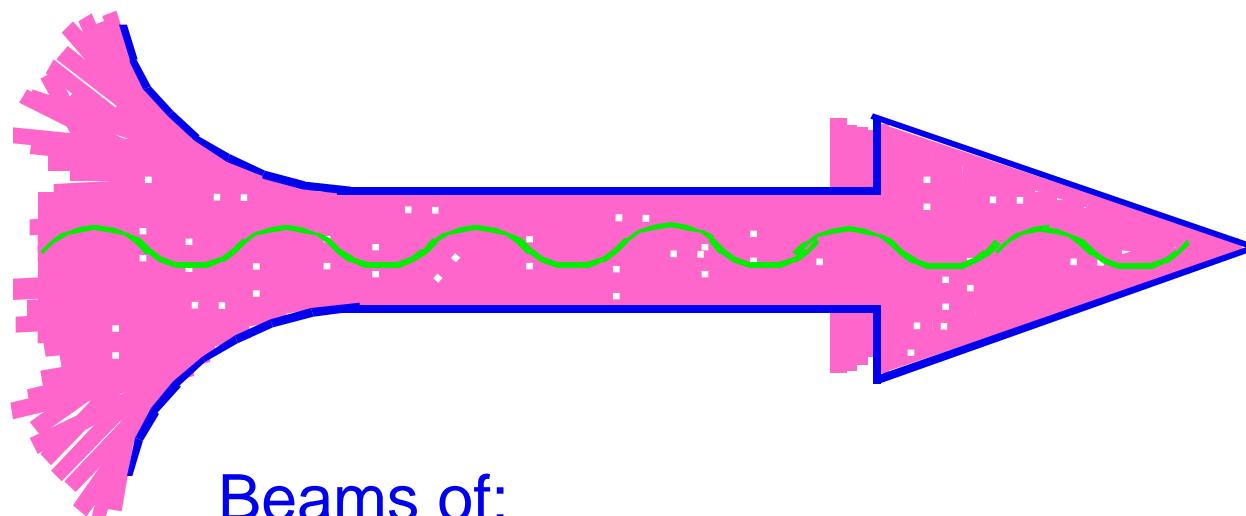


- Faraday Cup for Beam Instrumentation : W. Barry
- Wilson Prize in Accelerator Physics (APS) and D. R. Nicholson Humanitarian Award (APS) : A. Sessler
- Halbach Prize: W. Leemans and R. Schoenlein and team
- JAERI, 1995 Distinguished Visiting Scientist : S. Chattopadhyay
- APS Fellowships



BEAMS

Directed and Focused Flow of Energy and Information



Beams of:

- Particles: electrons, protons, ions, ...
- Ultraviolet, Visible, Infrared, X-ray, Photons ; Radio Waves ; Lasers



BEAMS :

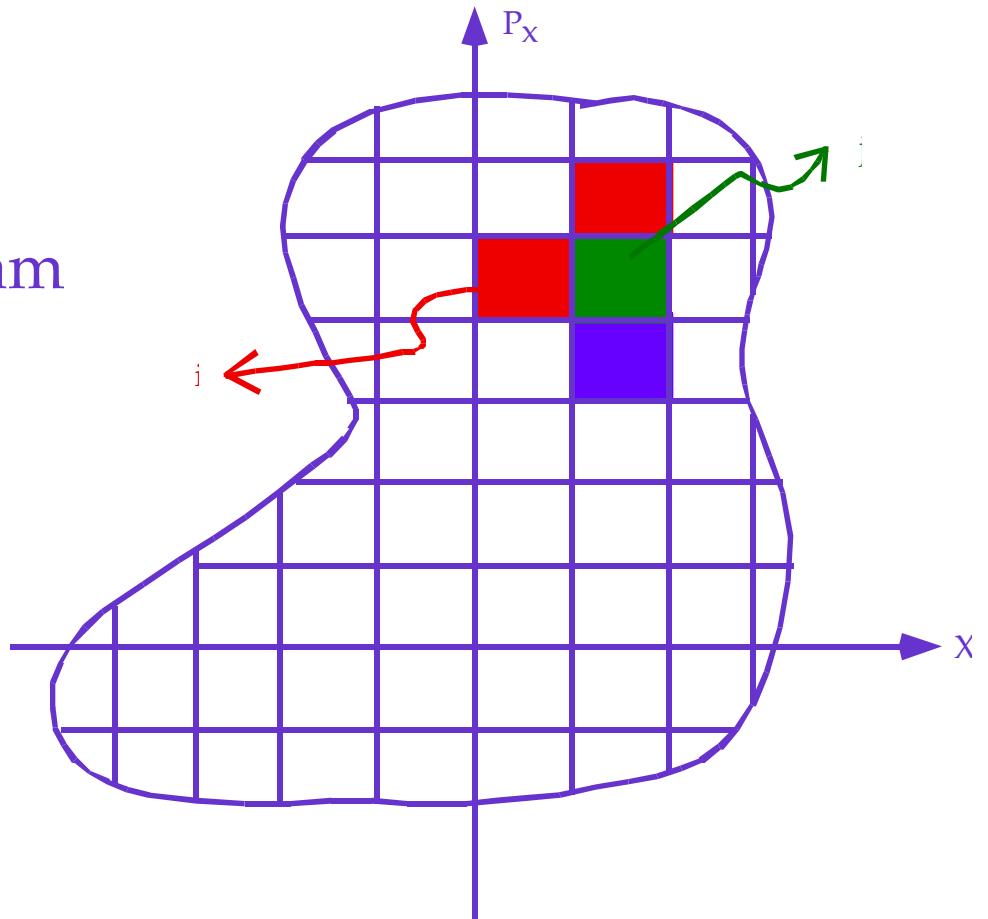
- Energy in a Beam

$$E_b \sim \sum_{i=1}^N [p_i^2 c^2 + m_i^2 c^4]^{1/2}$$

- Entropy & Information in a Beam

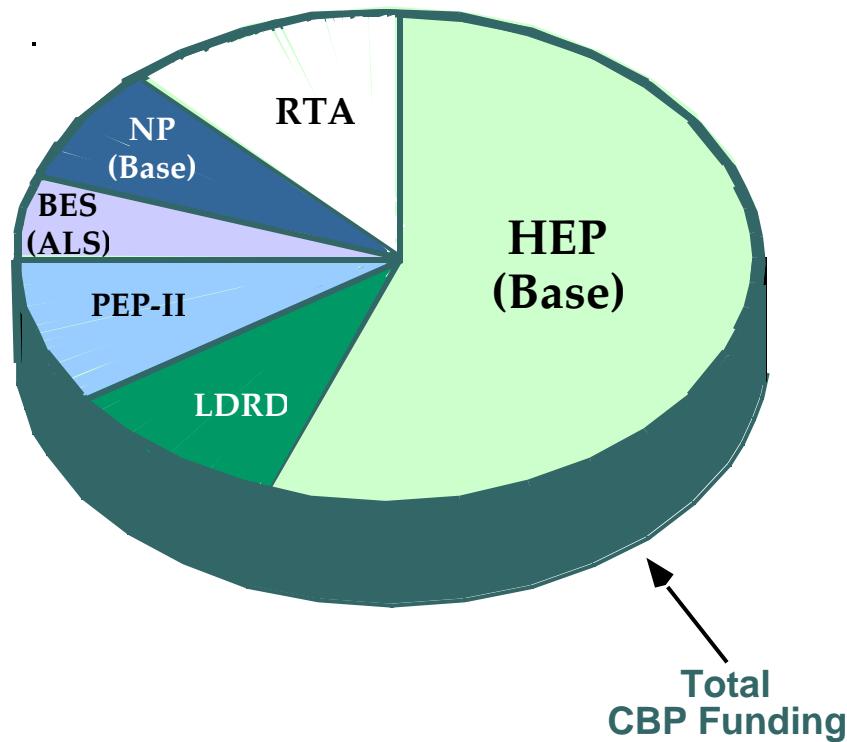
$$S_b \sim \sum_{i=1}^N n_i \ln(n_i) - 1$$

Phase Space in Rest Frame





CBP Budget : FY 1997



Operating:

~4,000 k\$

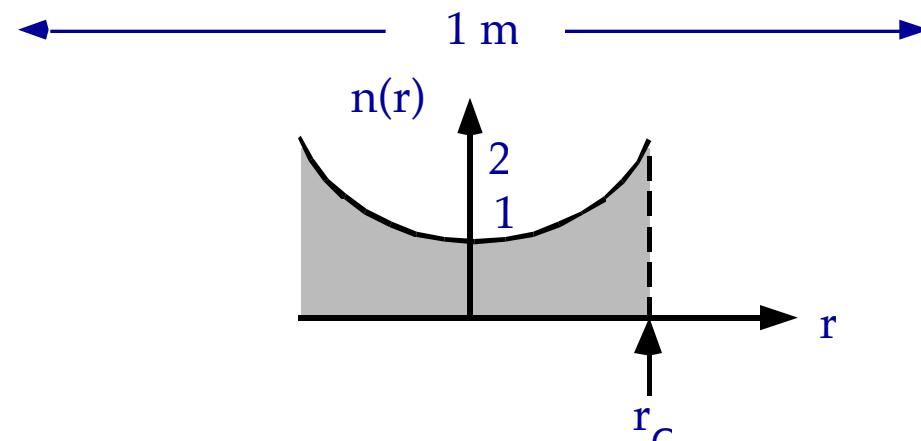
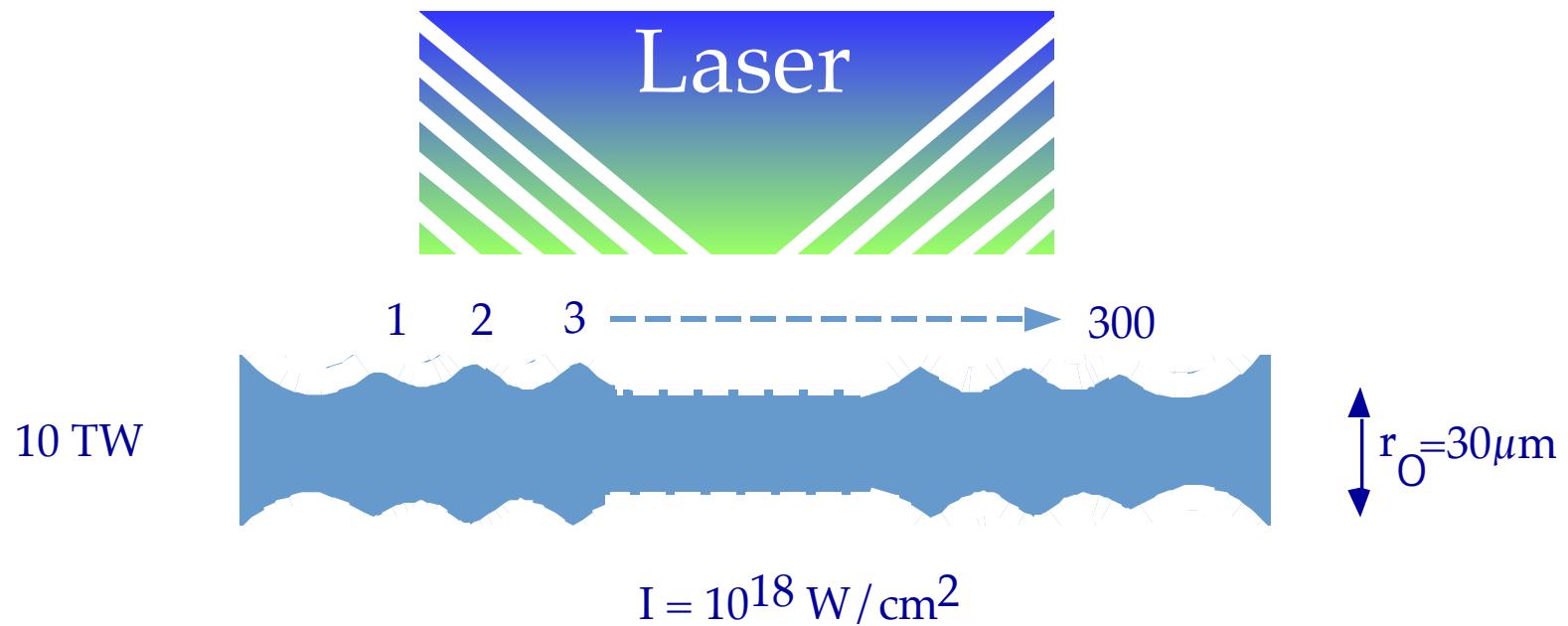
Equipment:

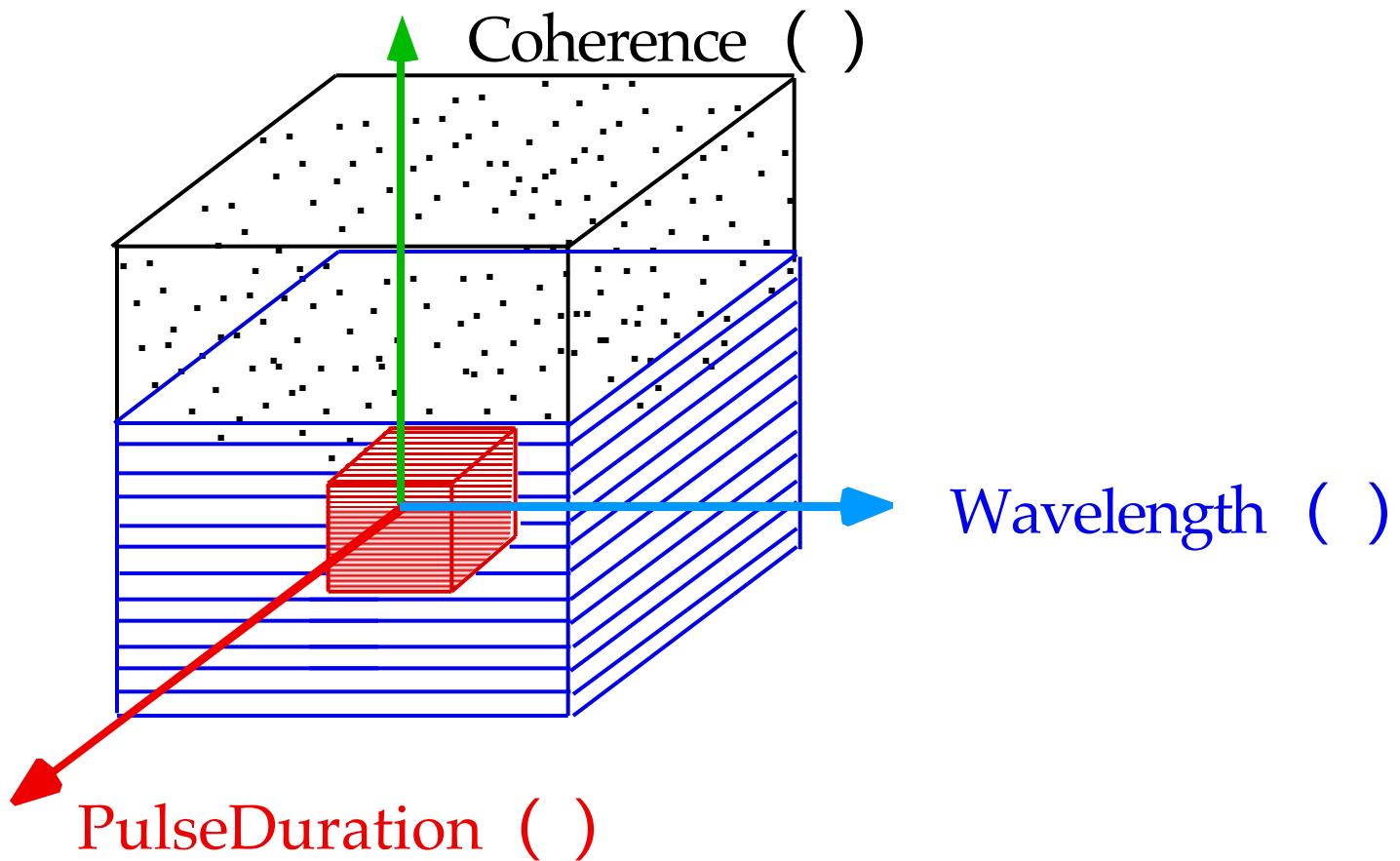
~250 k\$

- BES (ALS):** RF and Beam Control in the Advanced Light Source
NP(Base): Phase Space Cooling of Heavy Ion Beams in RHIC (BNL)
PEP-II: Asymmetric B-Factory at SLAC (SLAC-LBNL-LLNL)
RTA : Relativistic-Klystron Two-beam Accelerator
LDRD : Laboratory Directed Research and Development



Channelled

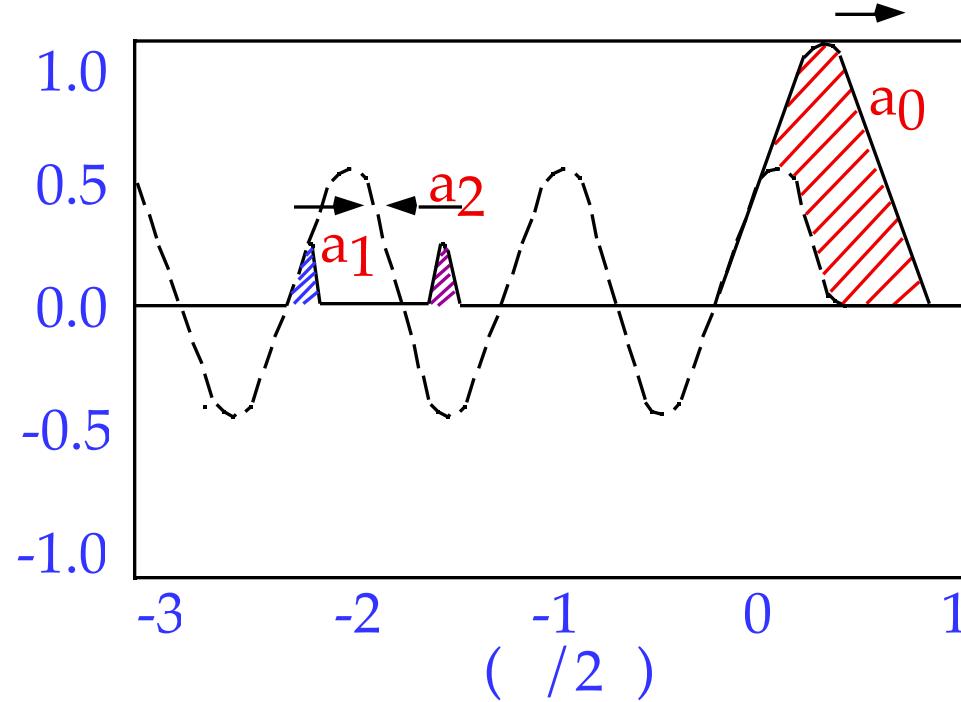




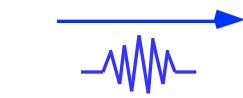


Colliding Pulse Injection & Laser Wake Acceleration

Normalized Potentials



$$\left(\frac{1}{2} \right)$$



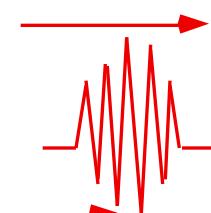
$(+\vec{k}, 1)$

a_1



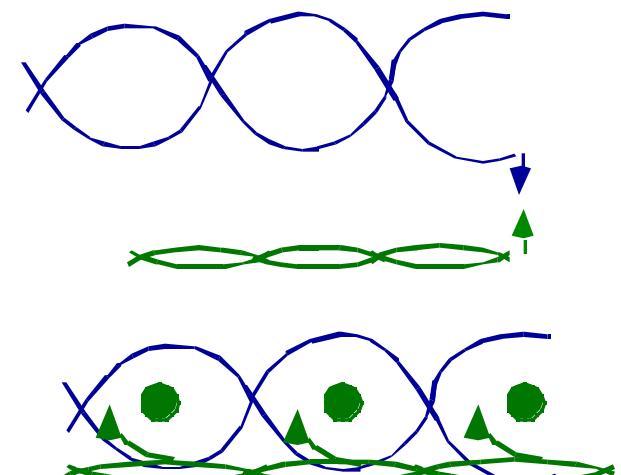
$(-\vec{k}, 2)$

a_2



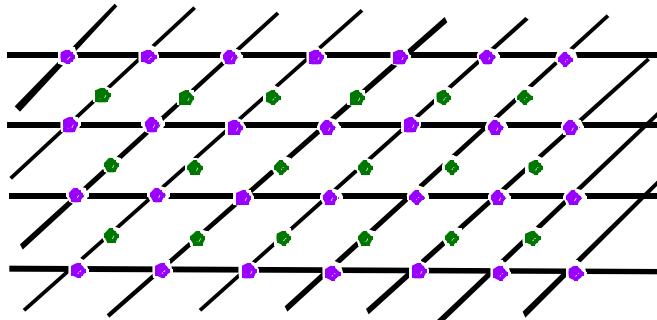
$(+\vec{k}, 0)$

a_0

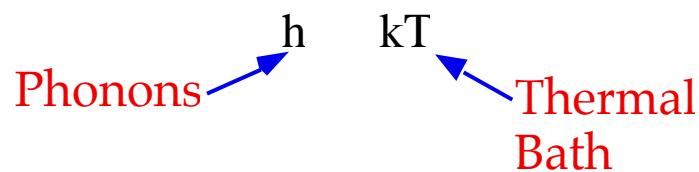




DYNAMICS ON A SURFACE



Lattice vibrations and 'Phonon' spectrum characterized by Debye time-scale :



Lattice relaxation time :

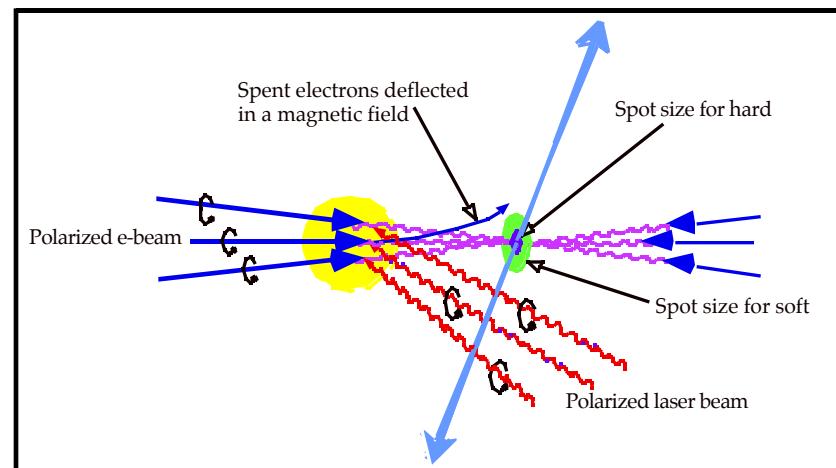
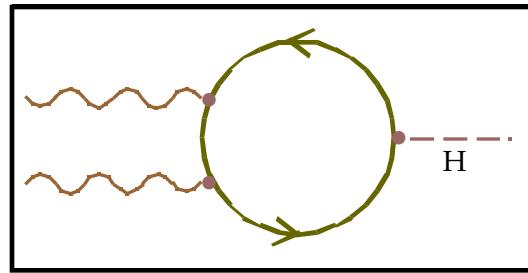
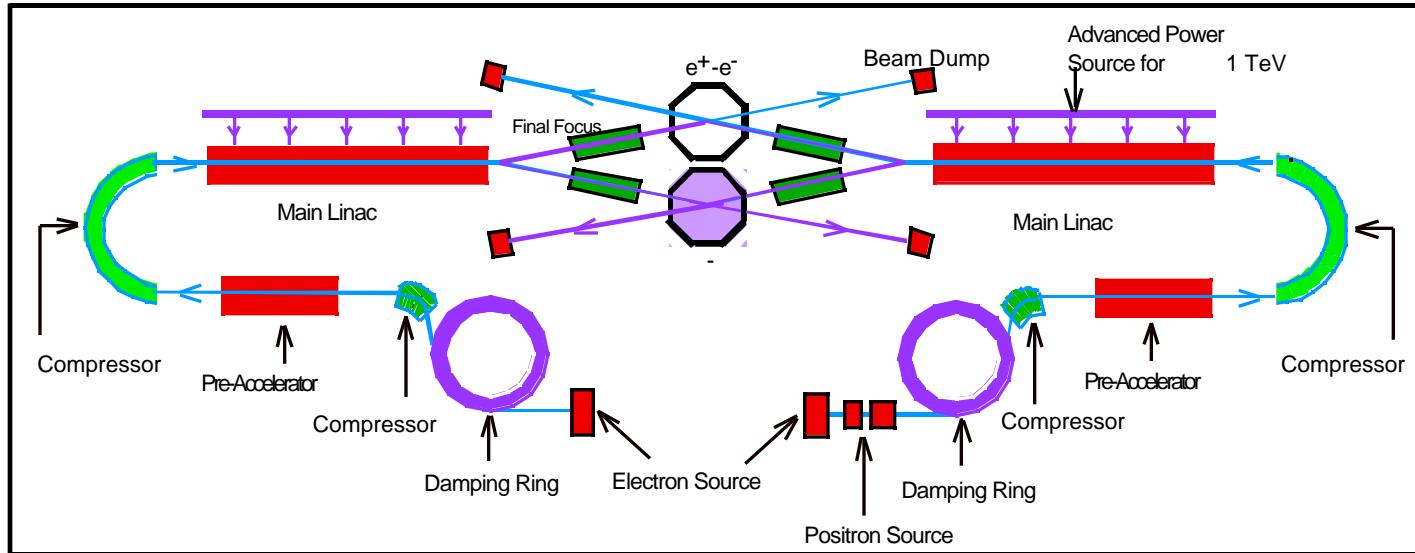
$$= -1 = h / kT$$

$\sim 100 \text{ fs}$ @ room temp.

e.g. PHASE TRANSITIONS like surface melting etc. take place on these 1 - 100 fs time-scale.
EXTREMELY VALUABLE INFORMATION for SEMICONDUCTOR PHYSICS. e.g. Silicon



e⁺e⁻ Energy Frontier



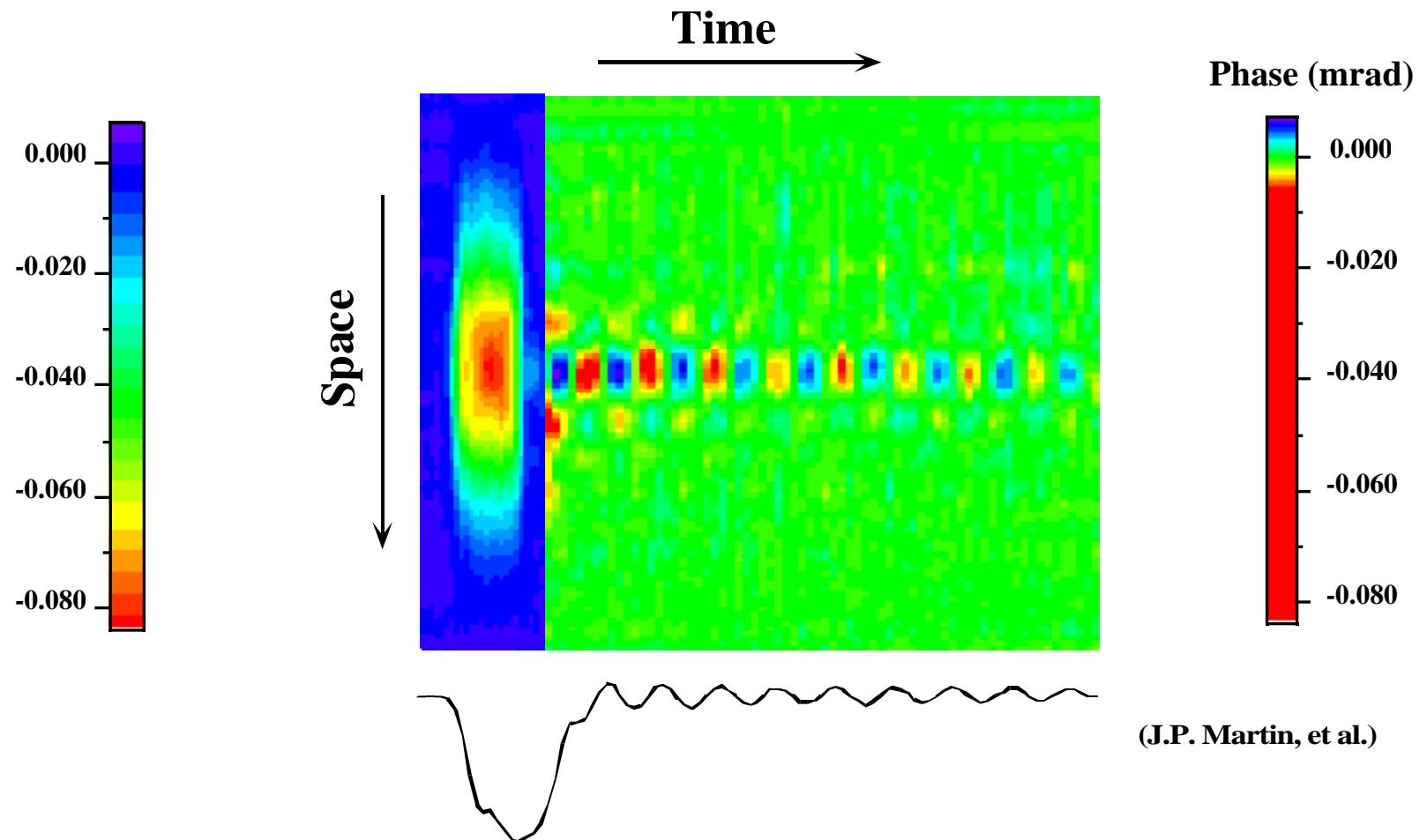


Educational Activities

- US Accelerator Schools :
 - UC San Diego, Winter '95-'96 (Beam Electrodynamics Group)
 - University of Maryland, Fall '96 (J. Byrd)
 - US-Japan Accelerator School, '96 (J. Byrd)
 - UC Berkeley, Winter '97 (J. Wurtele, K.J. Kim, J. Corlett, J. Byrd, S. Chattopadhyay)
- United Nations UNESCO School on Synchrotron Radiation, March '96 (K.-J. Kim)
- Regular graduate courses at UCB (Wurtele, Kim, Chattopadhyay)
- Graduate Seminar Class at UCLA
- Biweekly Center for Beam Physics Seminars
- Books generated: E. Forest. " Storage Ring Dynamics: A New Formalism" K.J. Kim, "Synchrotron Radiation", in preparation.
- Total number of students involved in program :
 - 11 graduate and undergraduate students altogether



Electron density oscillation



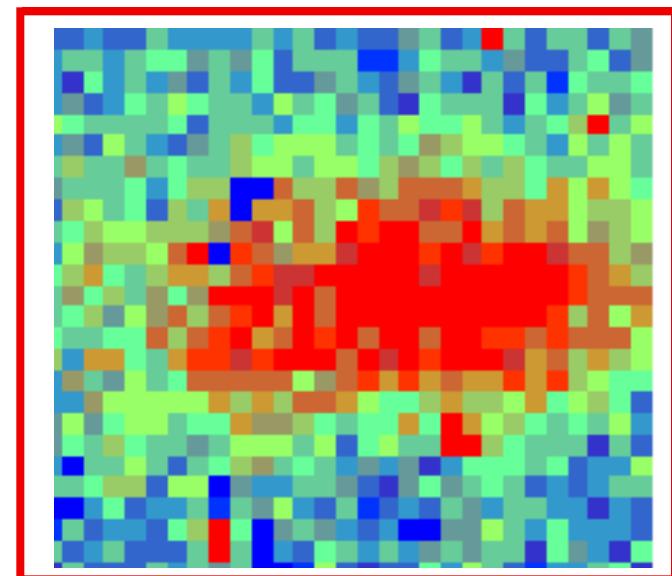
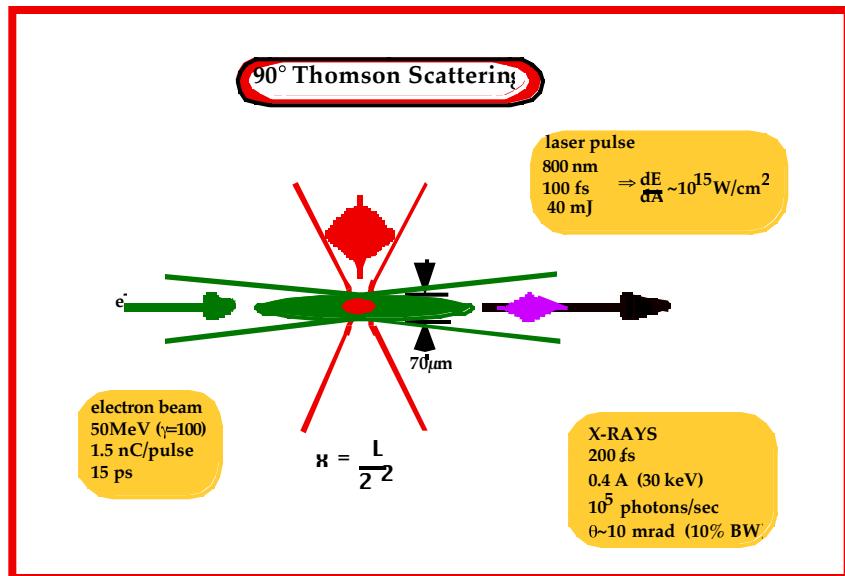
Experiments underway to address these two issues of 'guiding' and 'injection' at the Center's l'OASIS laboratory.....



talk by Wim Leemans

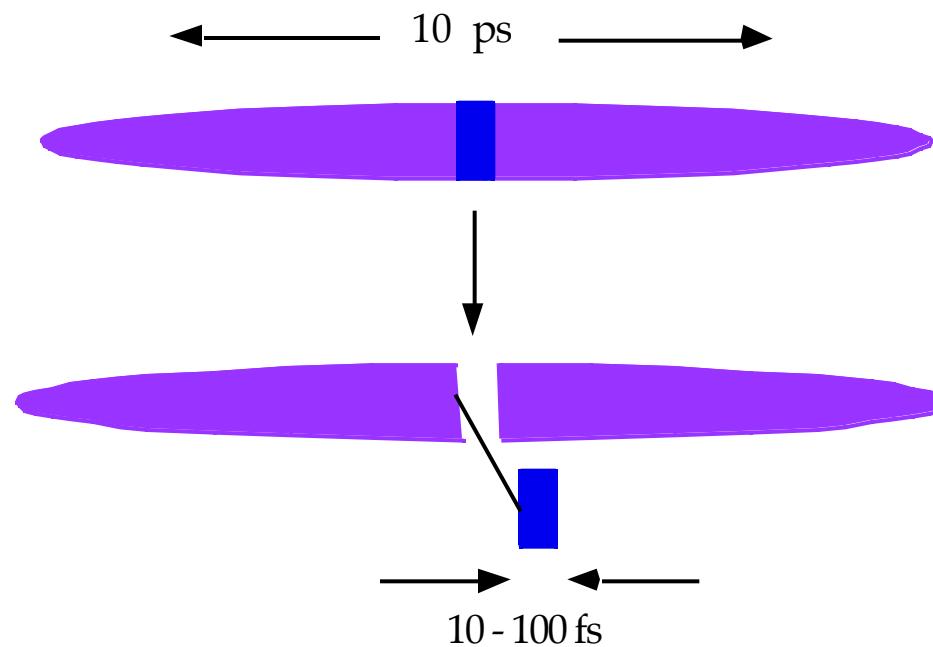


Femtosecond X-ray Image





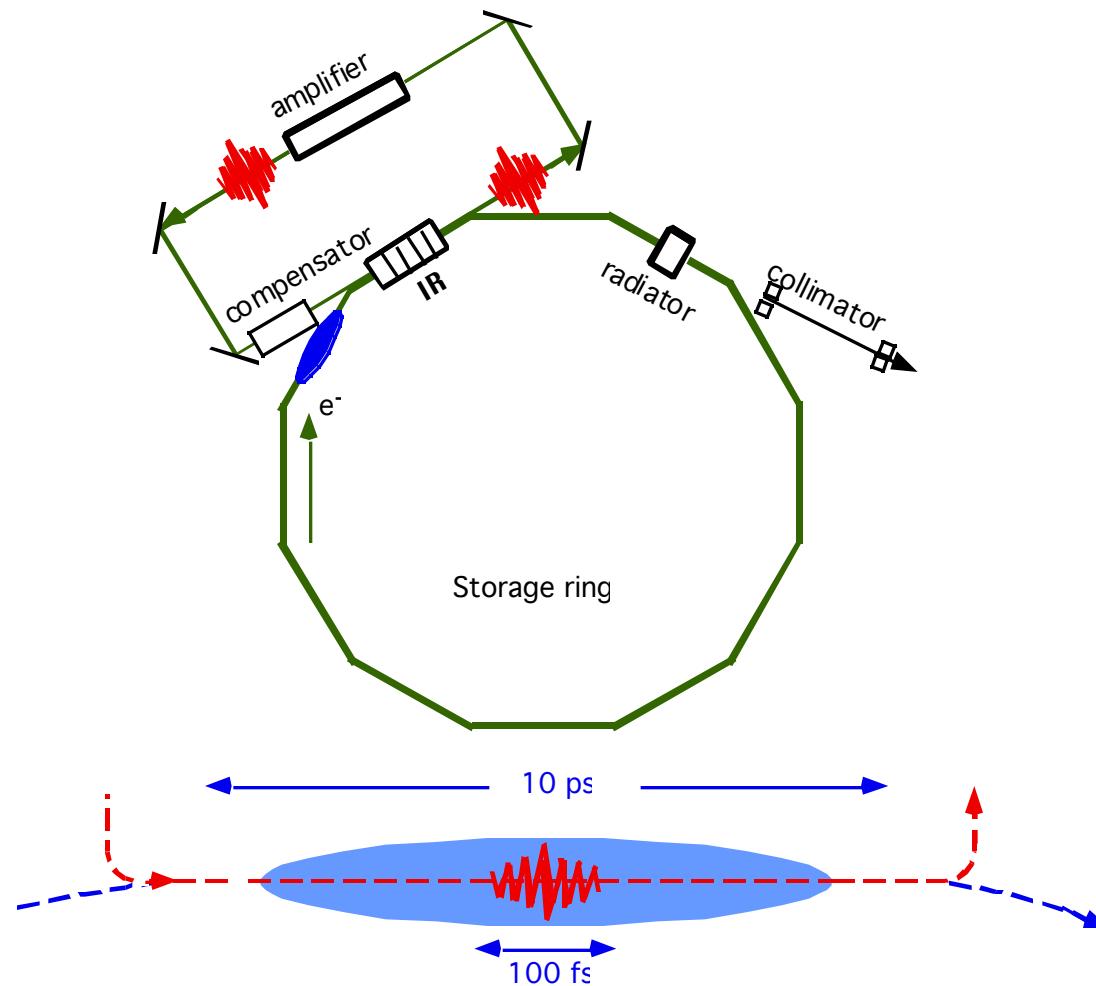
Femtosecond 'Tickle' and Slicing of Picosecond Electron Beams



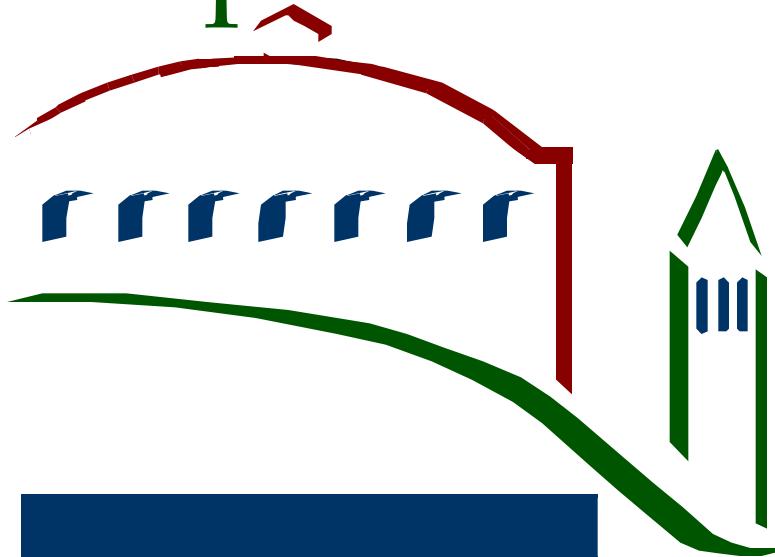


Femtosecond Slicing in a Storage Ring

Implementation in the ALS



"Laser Manipulation of Beams"



CENTERFOR BEAMPHYSICS

presented by
Swapan Chattopadhyay

Particle Accelerator Conference '97

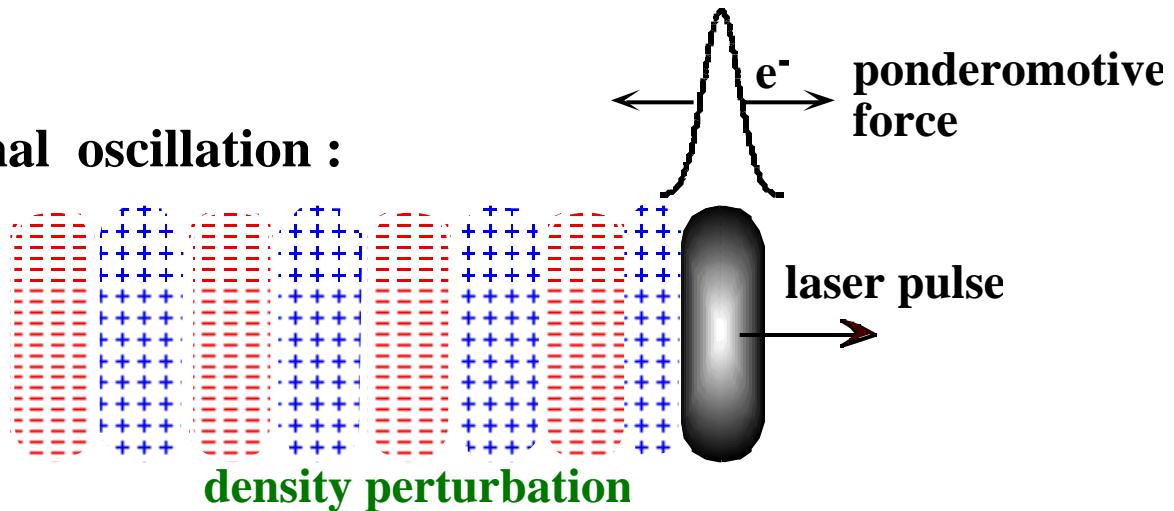
Thursday, May 15, 1997

Laser wakefield principle



Longitudinal oscillation :

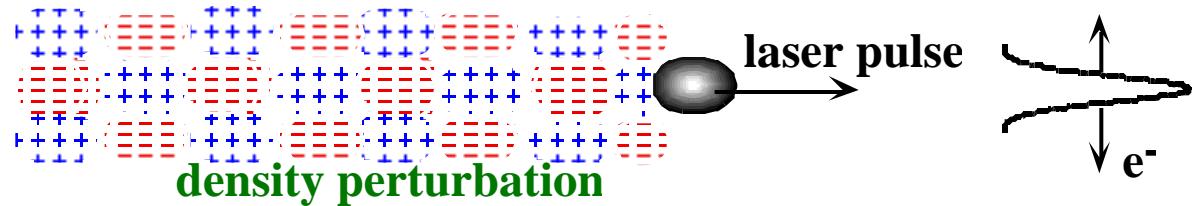
$$\begin{aligned} \rho &\sim 10^{19} \text{ /c.c.} \\ I &\sim 10^{18} \text{ Watts/cm}^2 \\ \downarrow & \\ E &\sim 50\text{--}100 \text{ GV/m} \end{aligned}$$



Longitudinal electric field with $v_\phi = v_g$ laser

Can be used for particles acceleration

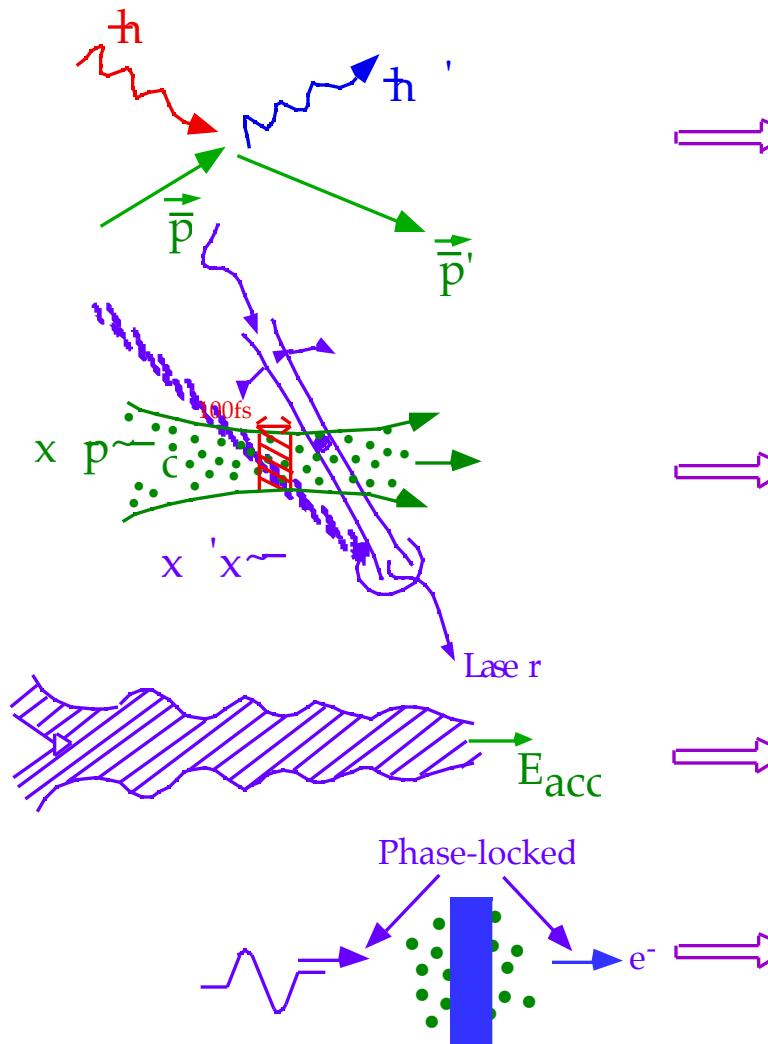
Transverse oscillation :



Transverse electric field with $v_\phi = 0$



Laser and Optical Manipulation of Beam Interaction



'SCATTERING' :
→ high energy photons
→ manipulate temporal & spectral profile

x-rays source

'PROBING' :
→ monitoring 'phase-space'
→ manipulate 'phase-space'

sub-ps time-resolved diagnostic, optical cooling

'CHANNELING' & guiding
→ Acceleration

'SYNCHRONIZED' ejection of particles → INJECTORS

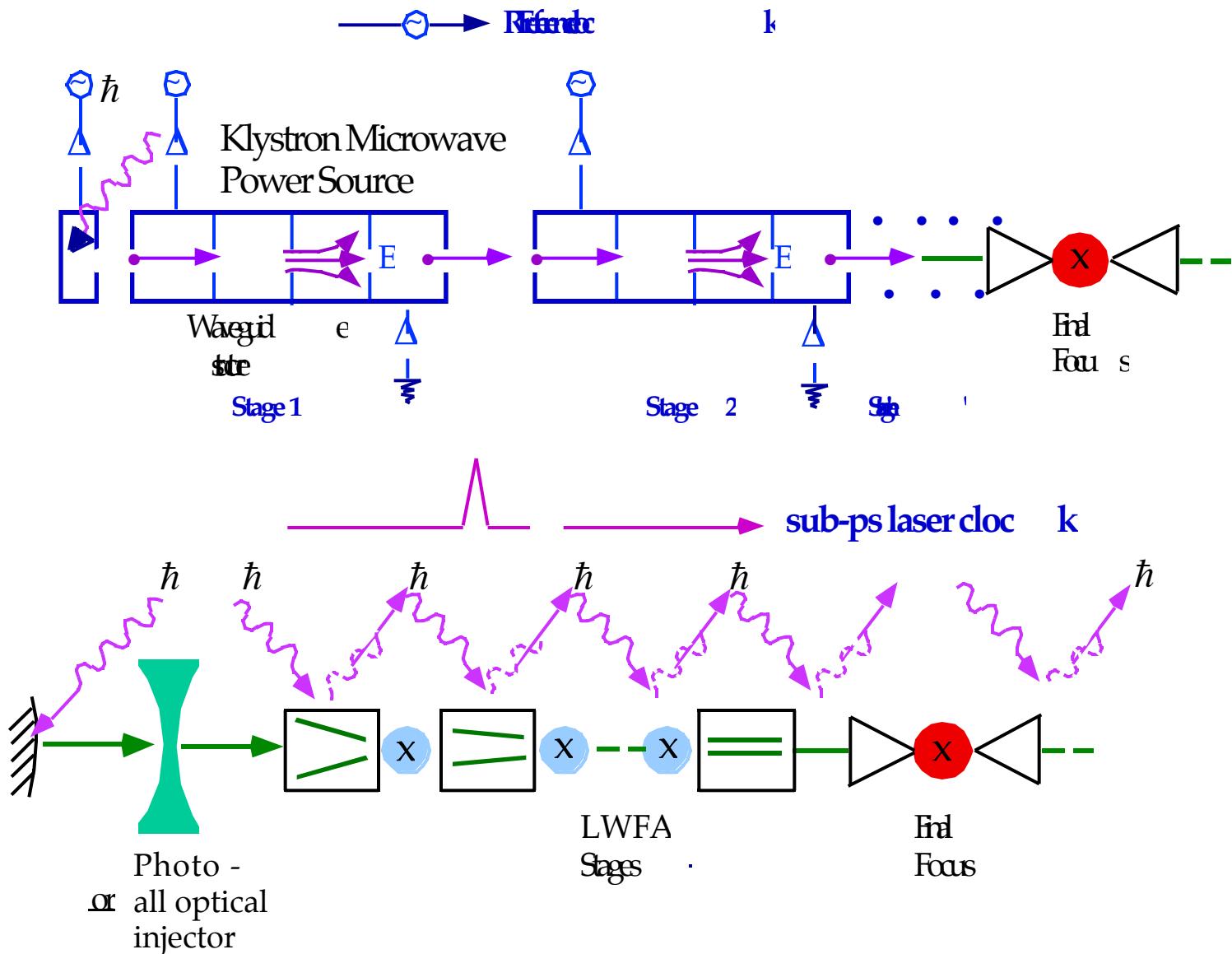


Memoranda of Collaboration and MOUs

- PEP-II (SLAC/LBL/LLNL)
- SLAC/LBL/LLNL on Next Linear Collider (NLC) ZDR
- CERN-CLIC/LBNL-CBP on Two -Beam Accelerator
- UC Davis/LBNL/SLAC - ATRI on Microwave Technology
- UC Davis-NEG/LBNL-CBP - AXF photocathode gun at 11.4 GHz
- Peking University-SCRF Dept./LBNL-CBP : on Superconducting RF photocathode development
- Kyoto University/LBNL-CBP : General Beam Physics
- Jefferson Lab/LBNL : FELs
- BNL-RHIC/LBNL-CBP : Beam Cooling in RHIC



Microwave Linac vs. Laser-Plasma Linac





Mission

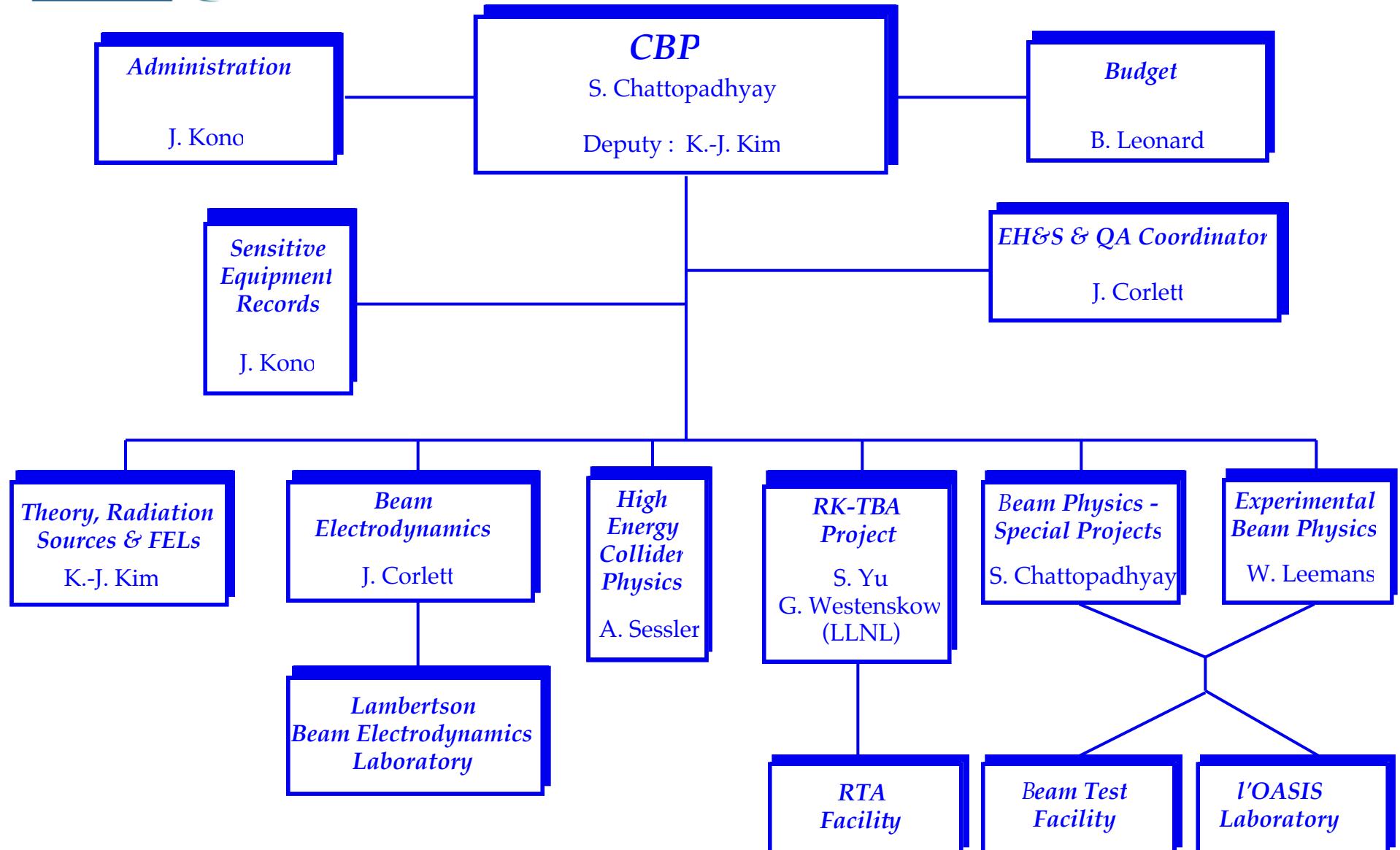
- Research and Development for the production, manipulation, storage, and control of particle and photon beams as applied to fundamental studies in natural sciences, energy sciences, industry and commerce.

High Energy Physics, Nuclear Physics, Material and Chemical Sciences, Life Sciences, Information & Power Beaming, Energy Production, Information Storage and Manipulation (computing), . . .

- Education of students, would-be practitioners and other segments of the community.



CENTER FOR BEAM PHYSICS





Outline

- BEAMS
- Mission
- Scope
- Research Output : Comments
- Budget
- Staff
- Organization
- Memoranda of Collaboration & MOUs
- Educational Activities
- Professional Services
- Sponsored Conferences & Workshops
- Awards & Honors
- Research Program
- Supplemtal material : MOU's, Linear Collider Collaboration & Publications List



Professional Services

- APS Vice President : A. Sessler
- APS/Division of Physics of Beams Executive Committee : S. Chattopadhyay
- ICFA Subcommittees : K.-J. Kim (Radiation Sources)
S. Chattopadhyay (New Methods & Techniques)
- Editorship of *Particle Accelerators* : S. Chattopadhyay, Editor-in-Chief,
Western Hemisphere
- Advisory and Program Committee of International and National Particle
Accelerator, LINAC and FEL Conferences
- Snowmass'96 : Accelerator Subgroup Convener (J. Wurtele)
Advanced Accelerator Technique Group Leader (S. Chattopadhyay)



Research Output : Comments

- Publications
- Many advanced tools: state-of-the-art codes developed and shared with community towards collider and SR source conception and design e.g., codes and methodologies for nonlinear dynamics in storage rings based on modern analytical and numerical algorithms using Lie - and Differential-algebraic techniques, symplectic integration, etc. Complete set of codes already used by other labs (CERN, SSC/LHC, SLAC, BNL, KEK, FNAL, DESY, etc) : TRACY-II, THOR, DAPASCAL, Six Track, ZAP, ABCI, MOSES.
- Large student participation and training



Research Output : Comments

- Beam Test Facility (BTF) : Advanced Experimental Facility for carrying out forefront R&D in advanced accelerator concepts in support of colliders & radiation sources of the future.
- New facility under preparation : l'OASIS (Laser-Plasma, THz & Quantum Optics for high energy physics & radiation source studies).
- Integrated with National Effort on US-CERN collaboration on the LHC & member of the International Collaboration on Linear Colliders via Interlaboratory MOU. Integrated with National Effort on Muon Colliders.
- Consolidation of expertise & resources in high power (Terawatt), short pulse lasers, plasmas, electron beams, quantum optics and microwaves towards advanced research in collider physics and synchrotron radiation sources.



Research Program

Current Activities & Future Opportunities

- High Energy Collider Frontier:

Hadrons & Heavy Ions :

- LHC : Beam dynamics, instrumentation and feedback at the IR
- RHIC : Instrumentation for luminosity and cooling

Leptons :

- NLC:
 - damping ring
 - final focus
 - gg
 - energy upgrade (RKTBA)
- PEP-II B-Factory (talk by M. Zisman)
- Muon Collider Studies

- Radiation Sources :

- Advanced Concepts & Technologies:

- New Thrust: Laser and optical Manipulation of Beams
Optical cooling, femtosecond x-rays, laser acceleration,
optical injection (talk by W. Leemans)



Scope

- The Center is involved in:
 - Conception, design, construction and commissioning of high energy colliders & synchrotron radiation sources (including FELs)
 - Beam physics R & D for advanced acceleration & radiation methods
 - Detailed measurements & proof-of-principle experiments in its four major facilities — the Lambertson Beam Electrodynamics Laboratory, the CBP l'OASIS Laboratory, the Beam Test Facility at the ALS & the RTA facility.
- The Center continues to provide core accelerator physics support for the PEP-II, LHC/NLC studies, some aspects of the Advanced Light Source (ALS), and has major collaborations with SLAC, LLNL, BNL, FNAL, Jefferson Lab, CERN, Stanford University, University of California at Davis and University of California at Berkeley, Kyoto University, Peking University,....



Scope

- Significant benefit is derived from existing accelerator programs & infrastructure, supported by various divisions of DOE.
 - BES/ALS for BTF
 - HEP
 - Fusion for RK-TBA
 - NP for Beam Cooling



Sponsored Conferences and Workshops

- Mini Workshop on Laser Acceleration — 1995
- ICFA Nonlinear Dynamics Workshop — 1996
@ Arcidosso, Italy together with SLAC and UCLA
- Advanced Accelerator Workshop — 1996 @ Lake Tahoe
(sponsored by DOE/HEP)
- Muon Collider Workshop — February, 1997 @ LBNL
- Muon Collider Workshop — May, 1997 @ Orcas Island



Staff Roster

Scientists & Engineers : Administrative Support :

ARCHAMBAULT, Leon
BARRY, Walter
CHATTOPADHYAY, Swapan
CORLETT, John
DiMAGGIO, Scott
DOUGHERTY, Jim
FURMAN, Miguel
KIM, Kwang-Je
LEEMANS, Wim
Li, Derun
LOZANO, David
RIMMER, Robert
SESSLER, Andrew
TURNER, William
XIE, Ming
YU, Simon
ZHOLENTS, Alexander
ZISMAN, Michael
ZOLOTOREV, Max

UCB Faculty Associates

FALCONE, Roger
VAZIRANI, Umesh
WURTELE, Jonathan

KONO, Joy
MITSCHANG, Faye
NOEL, Linda
PITTMAN, Illona
WONG, Olivia

Post-Docs :

OHGAKI, Tomomi
SHADWICK, Brad

Center Affiliates

DELAHAYE, J.P.
EDIGHOFFER, John
FOREST, Etienne
FREEMAN, Richard
GOUGH, Richard
HARTEMANN, Fred
HOUCK, Tim
LUHMANN, Nevill
PALMER, Robert
SCHOENLEIN, Robert
SHANK, Charles
TAJIMA, Toshiki
van BIBBER, Karl
VANECEK, David
WESTENSKOW, Glen

International/National Visitors

BAIER, V., BINP
DZERGACH, A., Moscow
JAGAMATHAN, S., Matsuiana
KHAN, S., Matsuiana
KOSTA, S., CAT
KRISHNAGOPAL, S., CAT
RAY, R., Calcutta Univ.
SERBO, V., Novosibirsk Univ.
TELNOV, V., BINP
WALTER, Olaf., Dortmund Univ.
YOKOYA, K., KEK

Students :

GOVIL, Richa
GUO, Kang-Zhu
LEE, Peter
LIDIA, Steve
LIE, James
PONCE-MARQUES, David
SCHROEDER, Carl
VOLFBEYN, Paul
WHEELER, Susan

Participating Guests

GARREN, Alper
GHIORSO, Albert
GOLDBERG, David
LAMBERTSON, Glen
PETERSON, Jack
VOELKER, Ferdinand



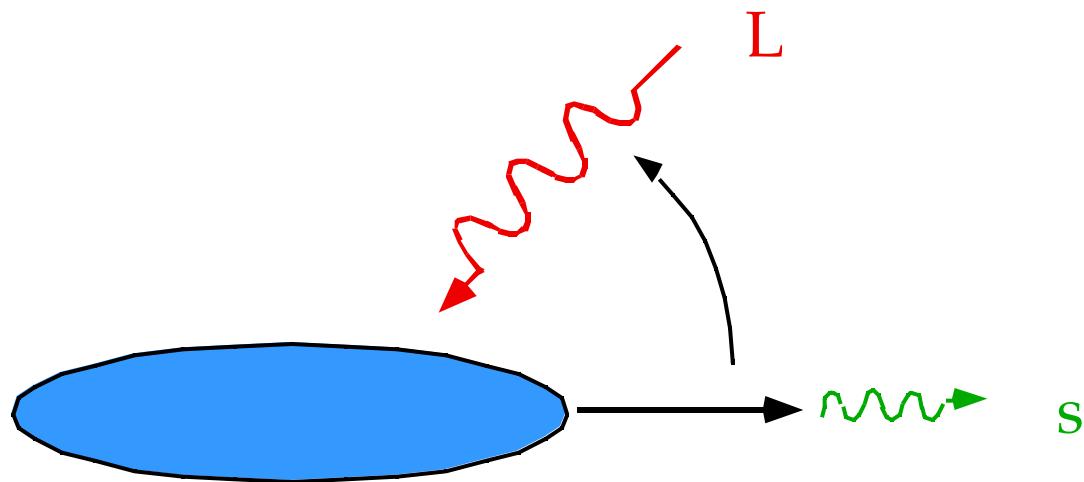
Snowmass'96

CURRENT STATUS OF 5 TeV COLLIDER RESEARCH

Technology	Wave-length λ	Potential Gradient	Collider Length	R & D	
				R & D	Technology Details
SCRF	>10 cm	100 MV/m	60 km	Superconducting materials research; new superconductor; site	'Bismuthate' materials
RF	1 cm	200 MV/m	30 km	Power sources prototype, drive beam dynamics, site sheet beam klystron research, site	30 GHz TBA 30 GHz Tube Drive n
mm-wave and THz	<3 mm	1 GV/m	<10 km	pwr source invention, structure invention, fabrication tech.	90 GHz Dielectric 90 GHz Conducting 1 THz
Lasers & beams in plasmas & structures	<300 μ m	>10 GV/m	~ km	module prototype, rep. rating guiding, staging, beam dynamics	laser structure-based laser plasma-based beam structure-based beam plasma-based
	relevant to all the above			~10 kHz rep. rate, TW peak power lasers, IR mechanical configuration	



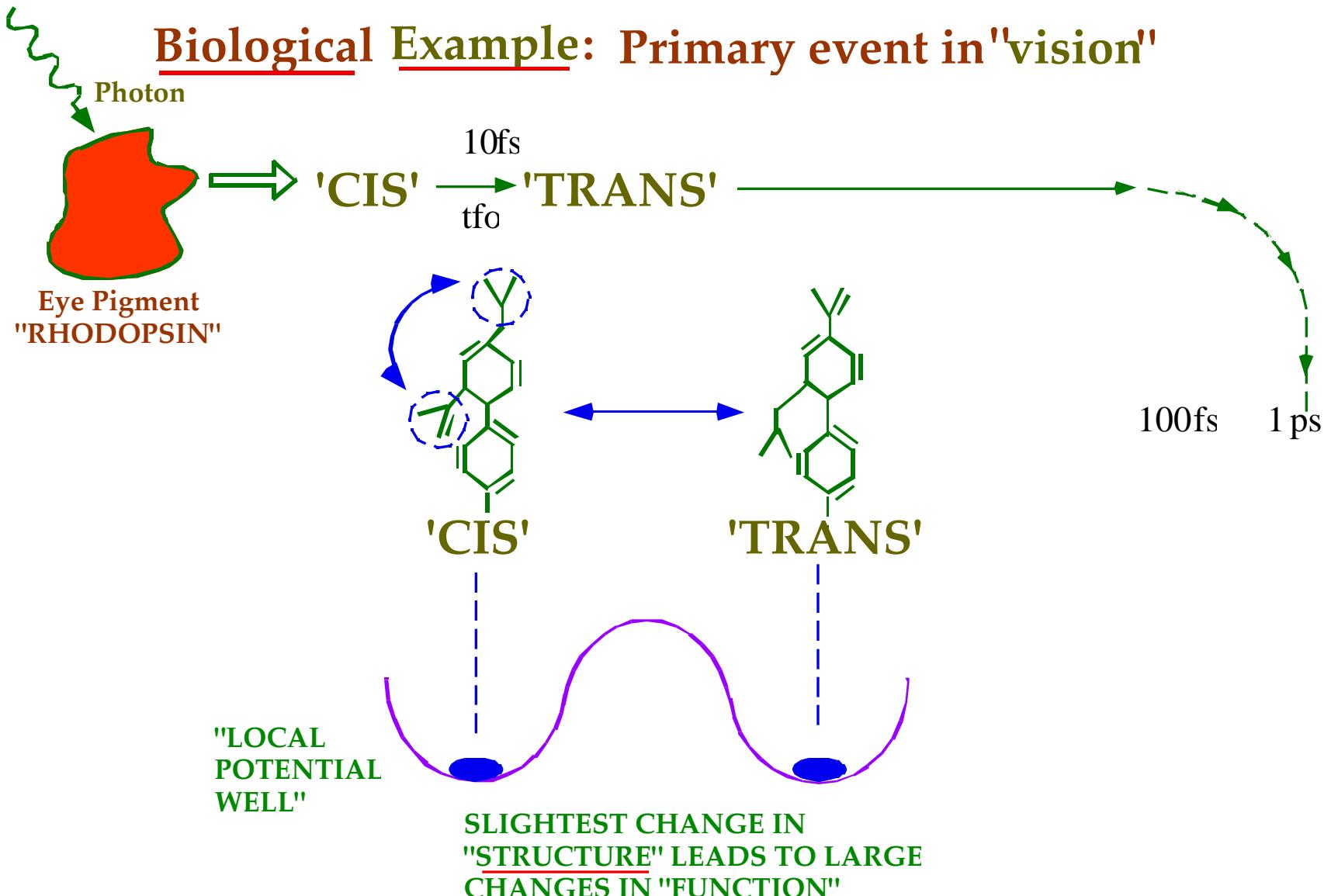
THOMSON / COMPTON SCATTERING



$$= C_s \frac{L}{2} f()$$



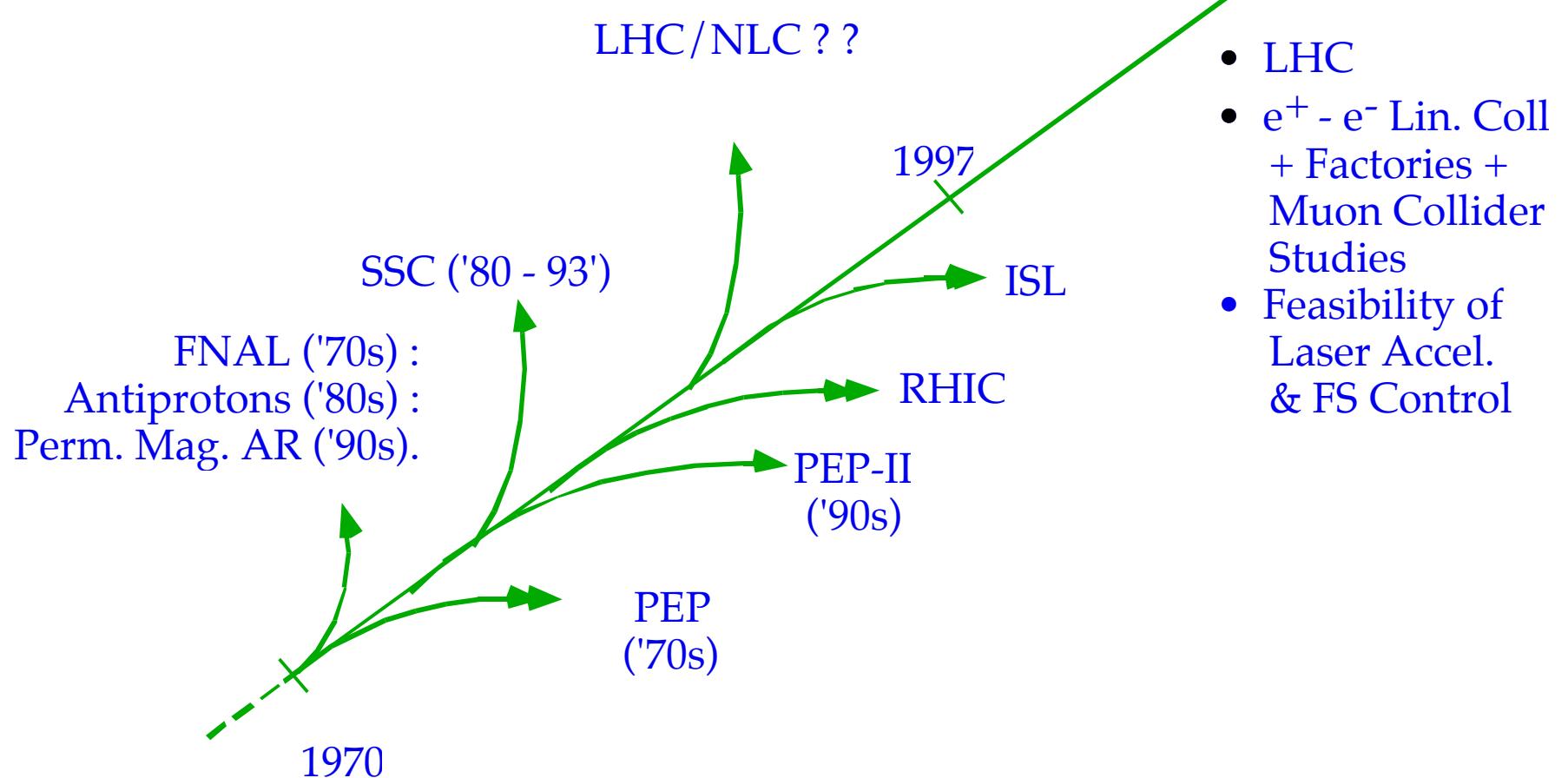
ULTRAFAST COHERENT CHEMICAL REACTIONS





Where From ? Where To ?

High Energy & Nuclear Physics





Where From ? Where To ?

Radiation Sources, etc.

